Validation of a Novel 3D Body Scanner for Obesity Anthropometric Measurements

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BACKGROUND

- Central obesity has been shown to pose a significant risk for cardiovascular disease, yet it is rarely ever measured in most clinical settings.[1-3]
- Waist and hip circumferences (WC, HC) are important measurements in defining central obesity.[4] Questions on their reliability have been raised.[5, 6]
- An automated 3D body scanner could potentially increase reproducibility of anthropometric measurements in clinical and epidemiological settings.

OBJECTIVES

This study was aimed to assess the validity and reproducibility of a 3D scanner in measuring anthropometric markers of obesity.

METHODS

Experimental Design: we studied the reliability of manual and automated anthropometric measurements. (Fig 1)

Subjects: Adults aged 18 – 75 years were considered suitable to be included in the study. Recruitment included healthy volunteers and patients enrolled in cardiovascular rehabilitation. Exclusion criteria included conditions that could affect the body volume (i.e., kidney disease, liver disease, myxedema).

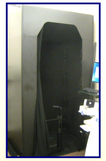
Measurements: All measurements were obtained by graduate students who had specific training on anthropometry and the use of the 3D scanner.

- **3D Body Scan:** The 3D BVI Body Scanner® (Select Research, UK) is a device that uses 32 cameras and 16 sources of light to take numerous pictures of the body in an automated process that takes <7 sec. A computer software (Select Research BVI software V.1.4) then creates a 3D image of the body and obtains several measurements (total/regional body volumes, WC, HC). The software finds predetermined body landmarks for anthropometry. WC is measured at 55% of height; HC is measured on its widest diameter by the scanner. (Fig. 2)
- **Anthropometry:** Weight was determined with a high-sensitivity scale to the nearest 0.1 Kg. Height was obtained by self-referral. To avoid measurement bias, we measured waist and hip circumferences using colored, non-elastic, unmarked ribbons using standard protocols, as defined by NIH guidelines.[4]

Statistical Analyses: Agreement for intra and inter-observer variability was assessed using paired t-test (JMP-SAS). Bland Altman plots were created to illustrate the reproducibility of the methods (MedCalc, Belgium).

1
Consent patient and fill questionnaires
↓
2
Patient changes clothes to gray spandex underwear
↓
3
1st 3D BVI Scanner measurement
↓
4
1st Anthropometry
-Measure hip and waist circumferences with colored ribbons.
-Waist circumference measuring technique:
1- With the patient standing straight, ask him/her to cross the arms over the chest placing the hands over the shoulders
2- Trace a line that crosses the lower rib edges and another crossing the iliac crests. Trace a third line halfway the first two
3- Ask the patient to take a deep breath and to breathe out. 4- Measure the waist circumference in the previous traced line
-Hip is measured in its widest point
↓
5
2nd 3D BVI Scanner measurement
↓
6
2nd Anthropometry

Figure 1 - Study protocol



3D Scanner

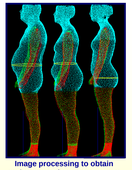
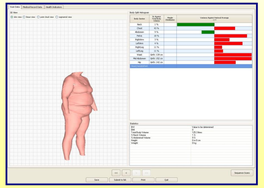


Image processing to obtain anthropometric measurements



Report from BVI Software

Figure 2. 3D BVI Body Scanner

RESULTS

- Eighty subjects (46% women) participated in this study.
- Age was 41.8 ± 18.2 years
- BMI mean (SD) was 25.7 (±5.1) kg/m^2 - range 18.4 - 42 kg/m^2
- Intra-observer mean difference for manual measurements was 3.01 ± 0.25 cm for WC, and 2.81 ± 0.43 cm for HC.
- The 3D-scanner variability for WC was 1.1 ± 0.1 and for HC was 0.9 ± 0.15.
- All p values for the comparisons between intra/inter-observer manual measurements and the 3-D scanner were <0.001.
- Bland Altman plots (Fig 3) illustrate the reproducibility of measuring waist and hip circumferences manually versus using the 3D scanner.

Variable	Mean ± SD / Number (%)
Source:	
Healthy volunteers	55 (68)
Patients in cardiovascular rehabilitation	25 (32)
Age, years	41.8 ± 18.2
Sex:	
Male	43 (54)
female	37 (46)
Race/ethnicity:	
White	58 (73)
Black	8 (10)
Hispanic	5 (6)
Asian	8 (10)
Other	1 (1)
Body mass index, kg/m^2	25.7 ± 5.1
Overweight (BMI 25-29.9 kg/m^2)	24 (29%)
Male	17 (40%)
Female	7 (18%)
Obese (BMI>30 kg/m^2)	18 (22%)
Male	7 (16%)
Female	11 (28%)

Table 1 - Baseline characteristics

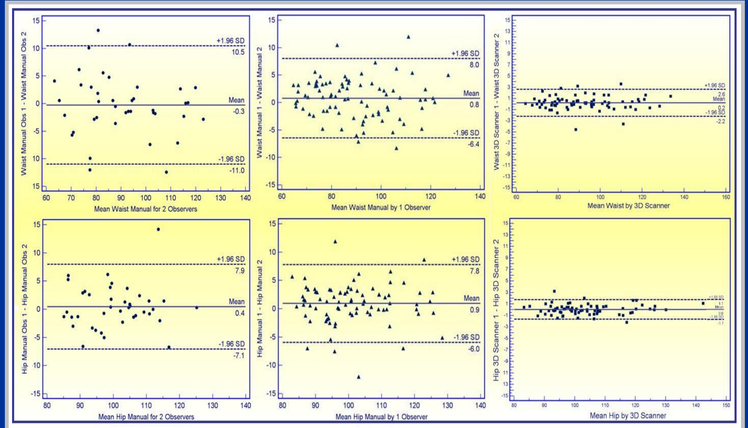


Figure - Manual and 3D Scanner Measures of Hip and Waist Circumferences

Bland Altman plots for WC (upper panel) and HC (lower panel). From left to right: variability between 2 manual measurements by 2 observers; variability between 2 measurements performed by the same observer; variability of the 3D scanner. SD: Standard deviation.

Measurements (in cm)		Lower value Mean ± SD	Higher value Mean ± SD	Difference Mean ± SE
Waist	Manual	87.84 ± 15.65	90.85 ± 15.93	3.01 ± 0.25
	3D scanner	91.62 ± 16.40	92.77 ± 16.55	1.15 ± 0.19
Hip	Manual	98.89 ± 11.41	101.71 ± 11.43	2.81 ± 0.43
	3D scanner	102.69 ± 11.30	103.59 ± 11.20	0.90 ± 0.15
Waist/Hip Ratio	Manual	0.88 ± 0.1	0.88 ± 0.1	0.006 ± 0.003
	3D scanner	0.88 ± 0.09	0.91 ± 0.09	0.003 ± 0.002

Table 2: Intra-observer Reliability

Measurements (in cm)	Observer 1 Mean ± SD	Observer 2 Mean ± SD	Difference Mean ± SE
Waist	89.97 ± 15.68	90.65 ± 17.06	0.30 ± 0.87
Hip	101.81 ± 11.50	100.38 ± 10.01	0.44 ± 0.61
Waist/Hip Ratio	0.88 ± 0.10	0.90 ± 0.11	0.0054 ± 0.011

Table 3: Inter-observer Reliability for Manual Measurements

DISCUSSION

- Results from recent studies have shown that manually measured waist and hip circumferences are unreliable, even after extensive personnel training.[5,6]
- Unreliability of manual anthropometric measurements could be related to how the methodology is interpreted and executed by different observers. The anatomical landmarks and the distances described in guidelines are imprecise and confusing.[2]
- An automated method that consistently measures anthropometric variables in a reliable fashion could increase the utility of central-obesity markers.
- Reliable measurements could improve risk stratification and identify effective actions for prevention.
- The results of the present study showed that a 3D scanner is a reliable and valid method to measure obesity-related anthropometric variables.

CONCLUSIONS

- A 3D scanner is a valid, reliable, and reproducible method to measure waist and hip circumferences.
- This study could make way for a novel method of diagnosing obesity in clinical and epidemiological settings.

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